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14. ABSTRACT This study examines the projected impacts of climate change on the nation of Colombia and explores their implications for its future national and regional security. It argues that many of Colombia's existing security threats, which stem from internal problems of poverty, social inequality, and persistent levels of organized violence, will likely continue in the future and be affected by climate change. The most likely climate-driven effects with security implications are natural disasters—particularly flooding—and the social and economic shocks these generate, and the security challenges entailed in large-scale human dislocation and economic change. In addition, several Colombian military bases are individually threatened by flooding or sea-level rise, and changes in river levels, sea levels, and the frequency and intensity of El Niño/La Niña events will affect to some degree tactical operations in river, jungle, and coastal operations. In regard to regional security, Colombia is likely to be called upon to participate in humanitarian and emergency relief. In a future context of limited government and international resources, it will be critical that countries of the region, including the United States, strengthen regional institutions that can coordinate joint planning and response to these relief efforts.						
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Impacts of Climate Change on Colombia's National and Regional Security

David M. Catarious, Jr., Ph.D

Ralph H. Espach, Ph.D



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Ronald Filadelfo
Environment and Energy Team
Resource Analysis Division

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Executive summary

Climate change presents a threat that goes far beyond the immediate disruption to our environment. The physical effects of climate change, such as sea level rise, droughts, floods and other extreme weather events, will lead to social and economic problems: large scale migration, crop failure, faster and wider spread of diseases, economic volatility, and resource competition. As such, climate change could act as a *threat multiplier*, exacerbating existing weaknesses and tensions around the world.

Colombia is likely to be affected significantly by climate changes by virtue of its tropical location, its extensive coastlines, and the reliance of the great majority of its people and industries on river systems and high-altitude water resources. The areas in Colombia expected to suffer the most dramatic changes are the high-altitude regions, the watersheds that are fed by high-altitude water reserves (including the economically vital Magdalena and Cauca River basins), the San Andrés and Providencia archipelago, and the Caribbean coastal area. These regions are home to more than 80 percent of the country's population.

Impacts of climate change on Colombia

Climate change will affect Colombia's natural systems and resources most directly through its impact on water resources. These are likely to take the following forms:

- **In the air:** Precipitation patterns will change across the country (both increasing and decreasing, depending on the region). Extreme

weather events, including hurricanes, heat-waves, wildfires, extreme rain storms, and El Niño/La Niña cycles, will become more frequent and intense.

- **In the mountains:** Warmer air and less humidity will threaten the Andean páramos, high-altitude wetlands that play a critical role in supplying and moderating the country's major river systems. The country's glaciers will continue to melt.
- **In the rivers:** River flow will diminish in general, particularly in the inter-Andean region, and river levels will be more volatile. Floods will increase in frequency and intensity.
- **In the soil:** Moisture levels in soils will decrease due to aridification, particularly in the Caribbean region and on high mountain plains. In these regions, rising temperatures will cause droughts of greater frequency and intensity. In other areas, flooding and volatile precipitation rates will increase soil erosion.
- **In the sea:** As with much of the rest of the world, climate change will increase sea levels on both of Colombia's coasts, inundating key areas of national, economic, cultural, and military value. Rising seas will also threaten natural resources by polluting fresh water aquifers and mangroves with sea water.

Implications for Colombia's national security

These pressures on Colombia's natural systems will impact its society, economy, and security in multiple ways. In general, climate change is unlikely to create entirely new security problems. Instead, it will act as a *threat multiplier*, exacerbating problems that already exist and stretching the capabilities and resources of the government, communities, and security forces.

The future security impacts of climate change in Colombia are unlikely to be new phenomena. Instead, climate change will worsen long-standing problems (e.g., drug trafficking and crime, natural disasters, forced migration or displacement). The security challenges likely to be of greatest future concern include the following:

- **Increases in the frequency and intensity of natural disasters.** These include floods, droughts, and (for the Caribbean coast) tropical storms. These impacts will increasingly overlap, having potentially severe humanitarian and economic effects.
- **Creating conditions that are conducive to illegal activities,** potentially worsening national crime and violence. Illegal armed groups and criminal organizations will benefit from climate-driven shocks and social disorder. The Colombian government, law enforcement agencies, and armed forces will be hard-pressed to respond to climate-related crises without diverting resources and attention from fighting crime and narcotraffickers. Also, illegal armed

groups may have some tactical advantages in responding to changing climate conditions due to the relative flexibility in their operations. Any increase in drug trafficking and organized violence will not only affect Colombia's national security, but security across the Caribbean basin and beyond.

- **Exacerbation of human displacement.** Climate change could drive displacement, both domestic and international, as a result of the increase in natural disasters and environmental and societal impact.
- **Growing pressure on the military's operations and resources.** While addressing their own needs to adapt facilities and operations to climate change, the Colombian armed forces will be required to provide security assistance, along with civilian partners, to the public. The damage to their infrastructure and increase in complex humanitarian missions will serve to divert resources from other missions and operations.

These problems will occur within a context of widespread pressures for adaptation. Colombia's government, its cities, communities, industries, and farmers will be facing their own needs for new or repaired infrastructure and systems, in addition to their concerns over increasing security challenges. Public budgets will likely be under great strain, and prioritizing among different needs will require strong political leadership.

Implications for Colombia's regional security

Colombia's neighbors are also likely to suffer dramatic effects from climate change. Regions in the Caribbean or Andes are expected to experience droughts and shortages of potable water, severe weather events, sea-level rise, the spread of vector-borne diseases, and agricultural declines caused by rising air temperatures. Likely follow-on effects include migration (particularly from rural to urban areas), energy and food shortages, human misery caused by storms and the spread of disease, and economic hardship caused by the lack of public funds necessary to address all of these problems. Most countries in the Caribbean basin and Andean region already struggle with the trafficking of drugs, weapons, contraband, and humans, and the violence and corruption that these activities generate. The follow-on effects from climate change are likely to make these problems worse. Some of the regional security problems that are most likely to derive from climate change, and to impact Colombia, include the following:

- **High demand for international emergency response.** It is highly likely that Colombia, with its relatively stable economy and greater infrastructural and military capabilities for emergency response operations, will be called upon to assist neighboring countries suffering climate-related crises.
- **Large-scale refugee flows are likely in the wake of some potentially devastating events such as drought, food, or water shortages.** These flows may also be driven by political conflicts caused partly by such crises. Some of these refugee flows may be transnational.

- **Social stress could lead to political tensions.** It is possible that climate-induced crises, such as drought or famine, may combine with conditions of intense social division or nationalism to spark international tensions.

- **Humanitarian and economic crises facilitate illicit activities.** Around the region these economic and social difficulties will provide conditions that favor illicit activities such as the trafficking of drugs, humans, and other contraband, with their significant social and economic costs.

- **Limited public resources for response.** Regional governments will have to take measures to mitigate the effects of climate change (e.g., building and repairing dams, ports, power plants, etc.) that will likely outstrip available financial resources, both domestic and international. These burdens will reduce the regional capacity for emergency response and other security-related missions.

- **Spillover effects across the hemisphere.** The security impacts in Colombia could also have secondary security impacts for countries beyond the region, such as the United States, in terms of worsening problems of trafficking and crime, and increasing demand for humanitarian relief and crisis response.

Introduction

Climate change presents a threat that goes far beyond the immediate disruption to our environment. The physical effects of climate change, such as sea level rise, droughts, floods and other extreme weather events, will lead to social and economic problems: large scale migration, crop failure, faster and wider spread of diseases, economic volatility, resource competition. As such, climate change could act as a *threat multiplier*, exacerbating existing weaknesses and tensions around the world.

Climate change in Colombia

Colombia is likely to be affected significantly by climate changes by virtue of its tropical location, its extensive coastlines, and the reliance of the great majority of its people and industries on river systems and on high-altitude water resources. As we will discuss in detail, the areas in Colombia expected to suffer the most include the high-altitude regions, the watersheds that are fed by high-altitude water reserves (including the Magdalena and Cauca River basins), the San Andrés and Providencia archipelago, and the Caribbean coastal area. 80 percent of Colombians live in areas highly vulnerable to climate change [1].

Colombia's neighbors are also likely to experience negative effects from climate change. Areas in the Caribbean or Andes are expected to suffer more extensive droughts and shortages of potable water, severe weather events, sea-level rise, the spread of vector-borne diseases, and agricultural declines caused by rising air temperatures. Likely follow-on effects include migration (particularly from rural to urban areas), energy and food shortages, human misery

caused by storms and the spread of disease, and economic hardship caused by the lack of public funds necessary to address all these problems. Like Colombia, its neighbors already struggle with the trafficking of drugs, weapons, contraband, and humans, and the violence and corruption that these activities generate. The follow-on effects from climate change are almost sure to worsen these problems.

Regional dimensions

Colombia continues to be strategically important to the international community for security reasons. The drug trade destabilizes not only Colombia and neighboring countries, but also consumer countries in Europe and North America. The Colombian government, under President Álvaro Uribe

Eighty percent of Colombians live in areas highly vulnerable to climate change.

Vélez, has pursued a strong security agenda that has reduced violent crime and has severely weakened the FARC (a prescribed terrorist organization) and other illegal armed groups. The United States has provided, through "Plan Colombia," significant support to the Colombian military to assist this effort as well as to help reduce the production and trafficking of narcotics. The drug trade has become the driving force of conflict in Colombia, providing the financial support that keeps the FARC and other illegal armed groups alive. In August 2009, the United States and Colombia reached provisional agreement on a Defense Cooperation Agreement (DCA). The DCA will facilitate bilateral cooperation on security matters in Colombia, including

narcotics production and trafficking, terrorism, illicit smuggling of all types, and humanitarian and natural disasters.

Recognizing the likely severity of climate change impacts in Colombia, their multiple implications in terms of the security of the Colombian people, and Colombia's importance as a regional partner and key ally of the United Kingdom and the United States, the United Kingdom's Foreign Commonwealth Office (FCO) asked CNA to examine the likely implications of future climate change effects on Colombia's national security. Also, the FCO asked CNA to consider the likely implications of these effects in terms of regional security. This report presents the results of that analysis.

Analytical method

CNA addressed this complex research question using a layered analytical approach. For estimates of future climate effects in Colombia and the region, we relied on the best sources we could find internationally and in Colombia. Our key sources are the Intergovernmental Panel on Climate Change (IPCC) 2007 report [2] and the research by Colombian experts that informed that report.

In order to assess the implications of the physical impacts on the nation and people of Colombia, we conducted basic research on Colombia's geography, demographics, economy, and infrastructure. This research benefited from numerous interviews conducted in Bogotá and in Washington, D.C. We used this knowledge, along with information about trends in the country's political system, to assess the country's degree of resilience in the face of climate change. This analytical step is based on previous CNA work in this area [3, 4].

The final step in our analysis was to combine estimates of climate change effects in Colombia, the assessment of Colombia's likely resilience, and considerations regarding Colombia's national and regional security affairs in order to delineate the most likely impacts of climate change for Colombia's national security. The timeline for this estimate is 30 to 40 years (or roughly 2040-2050). However, we do not strictly adhere to this timeline in regard to some issues, such as sea-level rise, the development of which is expected to take longer. In this effort in particular, we benefited from extensive interviews with Colombian defense and military officials, security experts, and public officials with expertise on specific security issues.

Analysis of potential future outcomes is always an exercise in informed speculation. We do not purport to be able to predict the future with accuracy. The scenarios we present as likely are simply based on assumptions about the relationship between recent and current trends and their future evolution¹.

The key assumption that guides our estimation of future events is that current trends in Colombia, in terms of its security, economy, and politics, will likely continue but to interact in complex ways with growing effects from climate change. That is, in addition to assessing the environmental changes driven by climate change, we examine the way that these changes could interact with Colombia's existing security threats, such as drug trafficking and crime, natural disasters, forced migration, or displacement. The sources of our data are described in detail in the appendix.

¹ In our estimation of future conditions we make no assumptions regarding politics, either within Colombia or across the region. Our core assumption is the same for security issues: we assume that decades into the future the region's political situation will be roughly similar to that of the last 20 years, since the end of the Cold War.

Chapter 1

Colombia today

Before we consider the potential impacts of climate change on Colombia and on its security, we must review the relevant features of today's Colombia. We begin with an overview of Colombia's geography, its capacities for responding to climate change, and its current security condition.

Geography

Anticipating the effects of climate change in Colombia is complicated by the country's magnificently diverse geography. Colombia has extensive coastlines on the Caribbean Sea and the Pacific Ocean, and three major Andean mountain ranges run through the center of the country from southwest to northeast. Alongside and between these ranges run Colombia's two major river systems, the Cauca to the west and the Magdalena to the east. It is among these mountains on high plains, and within these inter-Andean river valleys, where most Colombians live and where the great majority of Colombia's economic activity occurs. These roughly north-south river systems, which combine in the north to flow into the Caribbean Sea, are in many ways the lifeblood of the country.

These inter-Andean valley regions are fertile and have a temperate climate, though high-altitude regions tend to be dry and cold. The area along the Caribbean coast and the extensive savannah region in the west of the country tend to be dry. The region along the Pacific coast is among the wettest in the world in terms of annual rainfall. Roughly a quarter of the national territory is

Amazonian rainforest, but it is sparsely populated (mostly by indigenous peoples) and barely integrated into the rest of the country.

Colombia can be divided into five distinct natural and socio-economic regions. The main factor that distinguishes these regions of the country is their positions in relation to the three mountain ranges, which largely determine the direction of river flows and watersheds. The people in each region, and their economies, interact with their hydrological resources in different ways: via either coastal or riverine economic activities both extractive and industrial. These interactions with the land and water will have enormous implications as each re-

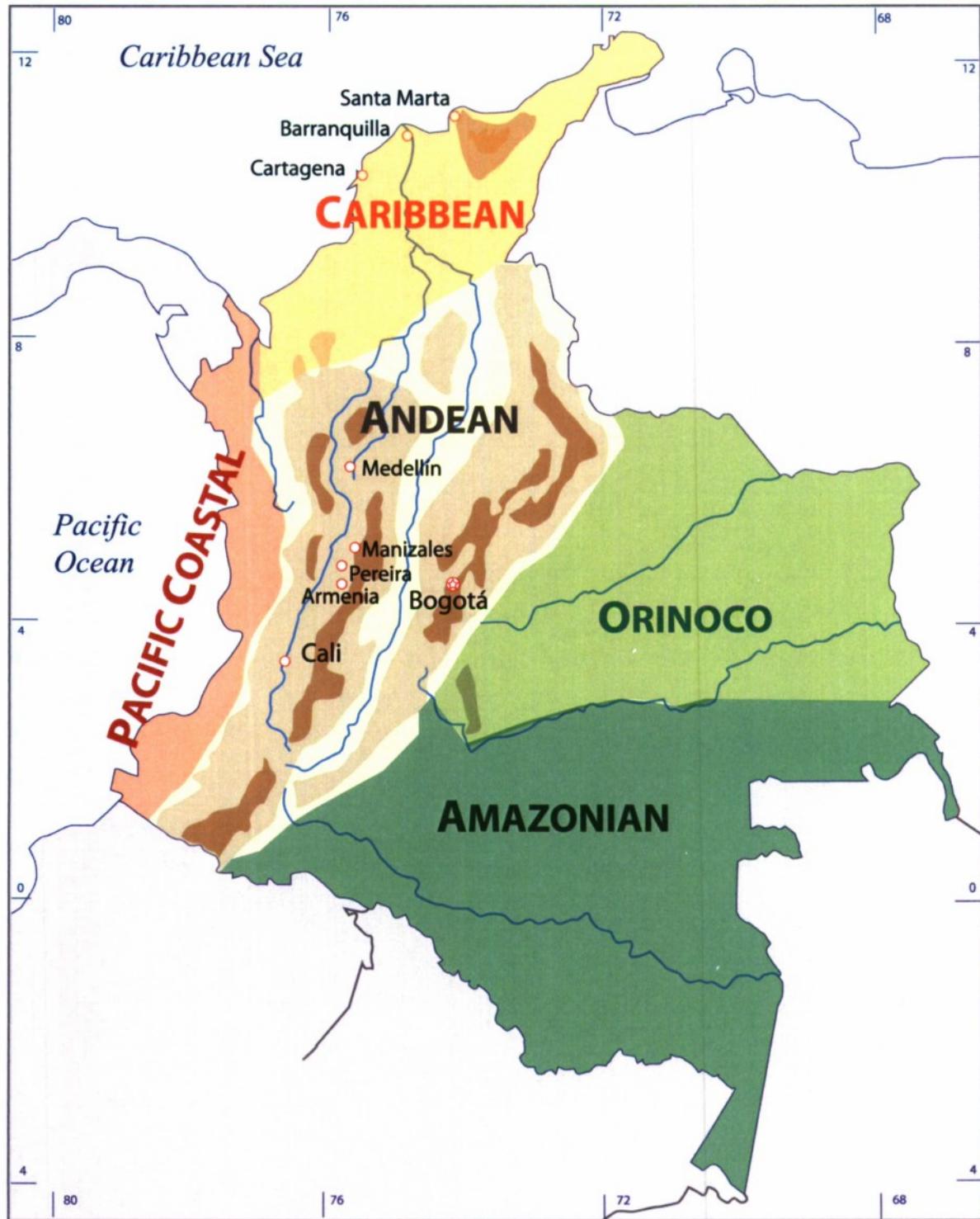
Anticipating the effects of climate change in Colombia is complicated by the country's magnificently diverse geography.

gion confronts different aspects of climate change (e.g., sea-level rise along coasts, rising or falling river levels, water shortages caused by the shrinkage of glaciers and moorlands/páramos).

Colombia's five major regions are: as shown in figure 1.

- The Pacific coastal region, fed by extraordinarily high quantities of rainfall, with a relatively small, low-income population residing mostly along the coast.

Figure 1: Colombia's five major geographic regions



- The Andean region, which runs southwest-northeast and includes the three mountain ranges and the country's major inland waterways (the Cauca and the Magdalena Rivers). The Andean region also includes the country's three largest population centers (Bogotá, Medellin, and Cali) and the great majority of Colombia's industrial facilities, energy reserves and facilities, and agriculture.
- The Caribbean region, which runs east-west along the coast, includes the country's most important port (Barranquilla) and naval base (at Cartagena).
- The Orinoco region, which is a savannah region of grasslands that runs westward from the Andean ridge with several rivers that feed the Orinoco River (Venezuela's major waterway).
- The Amazonian region in the southeast, consisting of scarcely populated rainforest. While much of this area is the property of indigenous groups, drug trafficking and processing is on the rise in the region.

Moderately high resilience to climate impacts

Many climate change experts and policy-makers have turned from debating the causes of climate change toward evaluating options for how countries may adapt their behaviors to mitigate its worst effects. Some have begun to consider not only where the effects of climate change are expected to be strongest, but also the local capacities (social, economic, and political) for response.

The Joint Global Change Research Institute, headquartered at the University of Maryland in the United States, has created an index that ranks 162 countries by quartile according to their current resilience to the effects of climate change. They define resilience as a function of a country's sensitivity (estimated by measures of its current ability to provide food, water, settlement, health, and ecosystem preservation) and its coping capacity (as measured by various indices of human resources, economic capacity, and environmental capacity) [5].

According to this index, Colombia falls in the second-best quartile of countries in terms of its current resilience. Colombia compares well, relative to most of its neighbors, in terms of the general access of its population to food, shelter, and health services, and the adaptability of its labor force² [6]. Colombia compares less favorably in terms of the realization of its human potential. This measure is affected by high levels of social inequity and marginalization³.

Colombia's economy is diverse and industrialized, and the country is rich in oil, minerals, agriculture, and hydrological resources (though the northern, Caribbean area of the country and the

² As of 2007 Colombia's GDP per capita (in purchasing power parity) was US\$7,304, similar to that of Panamá (US\$7,605) and significantly higher than those of Venezuela (US\$6,632) and Ecuador (US\$4,341). Its adult literacy rate (93 percent) and average lifespan (72 years) are also relatively high.

³ Most of the data upon which these scores are based were collected prior to 2004 when improvements in public security had not yet been made, so it is likely that this ranking somewhat underestimates Colombia's current position.

western savannah are relatively dry and suffer periodically from drought). This diversity should help Colombia be adaptive and flexible in the face of economic changes caused by climate effects. Colombia is also a net exporter of energy, and coal as well, and it generates almost two-thirds of its electricity from hydropower. All these factors suggest that Colombia is relatively well positioned, in terms of its economic and social capacities, for adapting to the coming effects of climate change.

If we consider the possibility that Colombia's internal conflict may have peaked and will likely be smaller or possibly nonexistent in the future, this development would free up significant economic and human resources that can be applied to more productive ends. For example, the World Bank estimates that if Colombia had been in peace for the last 20 years, the per capita income of the average Colombian today would be 50 percent higher [7]. It is reasonable, therefore, given the trend in this conflict, to speculate that in the coming decades Colombia's resilience may even increase.

Principal security threats are narcotics trafficking, insurgent groups, and natural disasters

Colombia is an industrialized and politically stable democracy. For over a century, Colombia has not faced a serious external threat. Instead, Colombia's security threats are rooted fundamentally in the country's internal instability and deficiencies, namely persistent high levels of poverty, social inequality, extreme rates of violence, and a massive population of internally displaced people.

According to the World Bank, 18 percent of the population lives on incomes of less than US\$2 per

...Colombia's security threats are rooted fundamentally in the country's internal instability and deficiencies...

day, and the country's social inequality is among the highest in Latin America⁴ [7]. Moreover, for decades Colombia has been among the world's most violent countries⁵ [8]. To some degree this is due to its internal conflict, in which the government has recently made important progress. However, despite dramatic improvements under the administration of President Álvaro Uribe Vélez, violence—and the poverty and inequality that feed that violence—persist across the country.

Rural populations tend to suffer disproportionately from these problems. Narcotrafficking cartels and insurgent groups have at times waged war within urban areas; however, various regions in the countryside have been affected severely by armed conflict among the military, insurgent groups, paramilitary groups and drug trafficking cartels⁶. Local

⁴As measured by the country's Gini coefficient, which is a common measure of income distribution.

⁵ In the last two decades, Colombia has often had among the world's highest rate of murders and kidnappings per capita, though these have fallen dramatically in recent years. But this violence was not a temporary problem. Today's key insurgent groups the FARC and the ELN originated from peasant self-defense groups formed in the 1940s and 50s during an era called La Violencia because of its rampant political violence.

⁶ In recent years, insurgent groups (particularly the FARC) have become increasingly involved with and dependent upon money from the trafficking of narcotics. As a result, these various types of illegal and violent groups have become increasingly interdependent and indistinguishable.

residents have frequently been victims of harassment and threats, have been driven off their land, or killed. Colombia's internally displaced population (those who have been driven by violence from their homes) is estimated to be between 3 and 4 million, or roughly 10 percent of the country's entire population [9], giving the country the second highest number of internally displaced people after Sudan. Other tens of thousands have fled across borders into Ecuador, Venezuela, or farther.

These factors—poverty, inequality, violence, and displaced peoples—are long-standing conditions that underlie many of Colombia's principal security threats.

Currently, Colombia's foremost security threats are:

- **Trafficking of illicit goods** (chiefly narcotics, but also including arms, precursor chemicals, and humans) and the violence, crime, and corruption this generates
- **Insurgent groups** that attack not only military or government targets but also civilians—often indiscriminately—and infrastructure. These groups survive largely due to proceeds from drug trafficking
- **Natural disasters**, particularly flooding but also drought, often related to El Niño or La Niña phenomena

The relationships among these threats and the underlying socio-economic conditions (poverty, inequality, violence, and internally displaced people) are complex and dynamic. For example, violence from narcotraffickers or FARC activities can drive people from their homes, forcing them into dis-

placement and poverty. Natural disasters may do the same. Once impoverished and desperate, these people may turn to crime or even join a narcotrafficking cartel or insurgent group in order to escape the situation⁷.

The regional effects from climate change are likely to cause problems in neighboring countries. These problems may spill over into Colombia or may demand Colombian response, which can divert Colombian resources from addressing the threats noted above. Though interstate armed conflict seems highly unlikely, climate change is expected

...an effective Colombian response will necessarily involve some degree of international coordination.

to generate stronger and more frequent weather events (e.g., El Niño/La Niña, hurricanes) and in some areas prolonged droughts and the permanent loss of high-altitude water reserves. These climate-induced changes are likely to generate periodic food and/or water shortages and could easily produce large-scale migratory flows including across borders. Because these effects are likely to be transnational as well as domestic, an effective Colombian response will necessarily involve some degree of international coordination.

⁷ This complexity is reflected in the Colombian government's efforts to address these problems simultaneously by combining, in specific areas of the country, military actions against insurgent groups and drug traffickers with an array of social and economic development services. Known as "Democratic Security," the plan is administered in large part by the umbrella agency Acción Social.

Chapter 2

Projected climate change effects and security impacts in Colombia

In this chapter, we explore the current and projected impacts of climate change on Colombia and examine how these pressures will interact with the nation's security situation. These projected impacts are based largely on the predictions calculated by the IPCC and Colombia's Institute for Hydrology, Meteorology, and Environmental Research (IDEAM)⁸. In general, climate modeling involves making assumptions about future conditions that depend on the interaction of several complex variables, such as economic growth, population dynamics, the response of non-linear physical systems, and political trajectory.

In order to account for the range of possibilities, the IPCC has defined a set of standard scenarios that are used by climate modelers. In this study, we discuss IDEAM's projected results based on two of these scenarios, known as the A2 and B2 scenarios. Briefly, scenario A2 describes a future with a continually increasing population, unevenly distributed economic growth, and slow technological progress. Scenario B2 describes a future where solutions to economic, social, and environmental problems are developed regionally, a growing global population (but at a slower rate than A2), and intermediate progress technologically. Each scenario is considered equally valid and only meant to capture a range of possible futures [10].

Due to Colombia's complex topography, modeling the impacts of climate change with specificity has proven demanding and difficult. The interaction of

the Andean mountains, humid coasts, arid lands, savannah, and tropical rain forests forms various sets of microclimates that exist in different regions of the country. As such, estimates of the climate impacts within Colombia are often given in a range of values rather than as a specific value.

A summary of the projected climate change impacts is shown in figure 2.

Temperatures will continue to rise

According to IDEAM, Colombia has been undergoing a steady rise in average temperatures since 1961. While the temperature record since 1961 has varied widely year to year, the average air temperature in Colombia has risen an average of 0.1° to 0.2° C per decade since 1961 [11].

By 2050 mean annual temperatures in Colombia are expected to increase by between 1° and 2° C as compared to temperatures between 1961 and 1990 [12]. In general, by the end of the century, temperatures are projected to increase by more than 4° C in some areas of the country, with much of the country experiencing a 2° to 4° C average annual increase [11]. This would mean that temperatures in present-day Medellin would approach those of present-day Cali, and Cali's temperatures will approximate those on the present-day Caribbean coast.

While there are differences in the projections under these scenarios, there are important areas of agreement. In both scenarios, the Magdalena

⁸ For more details about IDEAM see appendix 1.

River Valley (particularly the area between the Cordillera Central and Cordillera Oriental) is expected to experience a temperature rise of more than 4° C by the end of the century (as compared to the average between 1961 and 1990). The other areas for which both scenarios predict the most extreme temperature rise are in the border regions of Norte de Santander and along the northern stretch of the Magdalena River where the Bolívar, Magdalena, and Cesar Departments meet.

Under both scenarios, the mountainous areas of highest elevation will experience warming in the range of 0° to 2° C. The models agree that much of the area between the Pacific coast and Cordillera Central will experience end-of-century warming of between 2° and 4° C. The archipelago of San Andrés and Providencia is expected to increase in temperatures between 0° and 2° C.

The models differ for their prediction of the area of Colombia east of the Cordillera Oriental, with scenario B2 predicting smaller temperature rises than scenario A2.

The effects of climate change in Colombia are best understood by examining its impacts on one of its most abundant natural resources: water.

When overlaying these predictions with maps of the existing temperature averages, a pattern emerges: high mountain regions that have the coolest annual temps (cooler than 12° C) will experience the least degree of warming, while areas

that are already among the warmest regions (averaging more than 24° C) will experience the greatest degree of warming.

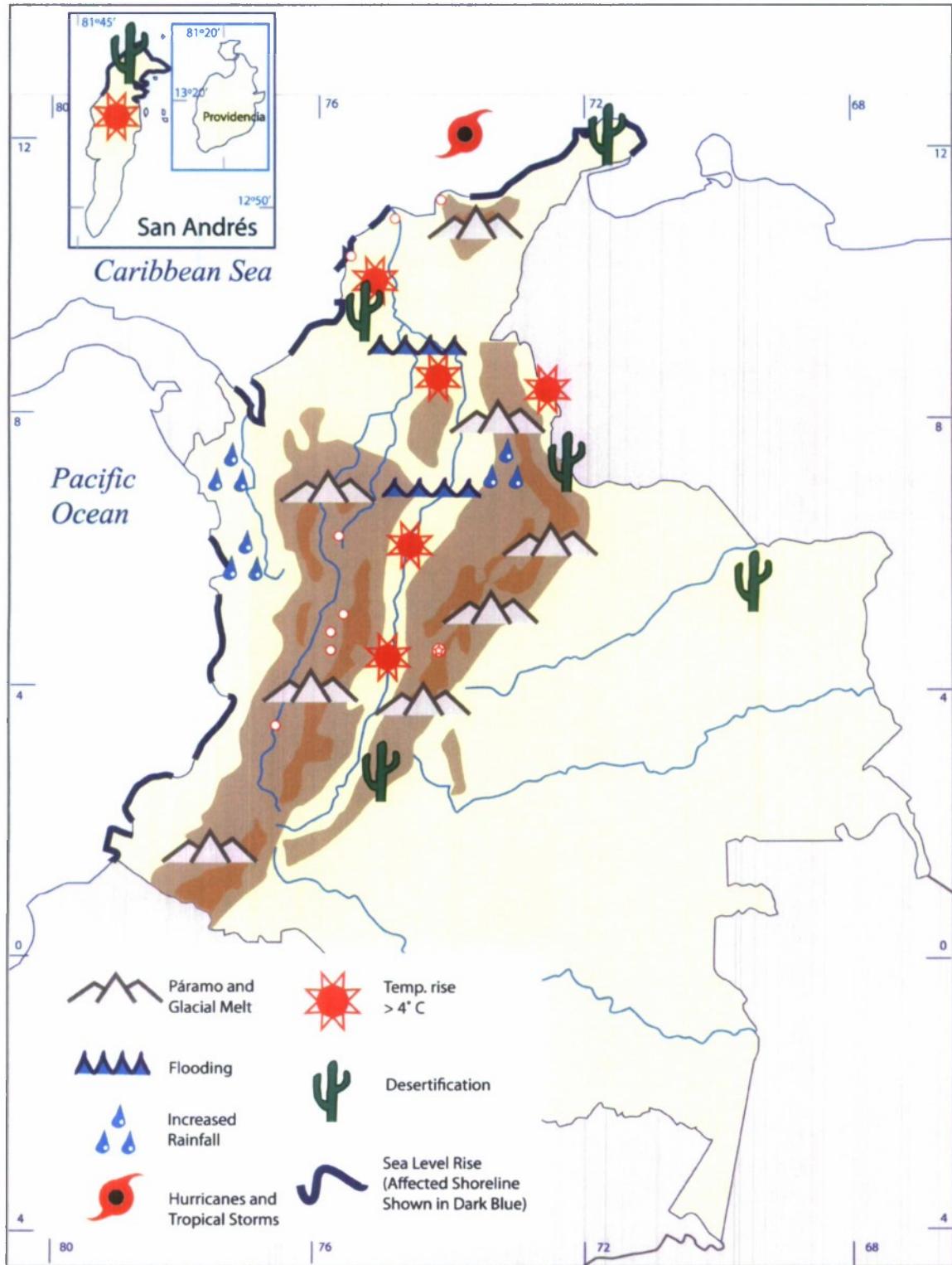
Through its effects on surface temperatures, climate change impacts many of the Earth's physical systems. Through various mechanisms these changes to Colombia's natural systems will have a marked impact on the security situation, chiefly by complicating the provision of several basic human needs (e.g., access to water, health, shelter, and markets), stressing the nation's military infrastructure, exacerbating natural disasters, and contributing to the internal unrest caused by violence and displacement.

Impacts revolve largely around Colombia's water cycle

The effects of climate change in Colombia are best understood by examining its impacts on one of its most abundant natural resources: water.

On a per capita basis, Colombia is one of the most water-rich nations in the world and, as a whole, experiences little to no water stress [13]. Colombian territory includes a good portion of the Amazonian rainforest, and the Pacific coastal region of Colombia is among the wettest on the planet [14]. However, Colombia's rich water resources are not equally distributed and are subject to seasonal, weather, and regional differences as well as the pressures of demography, urbanization, and contamination. Colombia is also the only country in Latin America to be bordered by both the Pacific and Atlantic Oceans.

Figure 2: Summary of projected climate change effects



We will examine the impacts of climate change on Colombia by tracing its water in all of its forms: in the air; in the mountains; in the rivers; in the soil; in the seas.

In the air: higher extremes in rainfall

Over the last five decades, the impact of climate change on precipitation has varied regionally, decreasing by 4 percent per decade in some areas while increasing up to 6 percent per decade in others [11].

IDEAM's models predict that for the Amazonia and Orinoquia regions, precipitation patterns will remain within 10 percent (increase or decrease) of the levels experienced between 1961 and 1990. There are a few exceptions to this assessment: in scenario A2, there is expected to be between a 10 and 30 percent reduction for some small areas in the eastern reaches of Vichada Department (near the Venezuelan border) and along the borders of Arauca and Casanare Departments (just east of the northern tip of the Cordillera Oriental).

While Amazonia and Orinoquia will remain within 10 percent of their historic values, significant stretches of the Caribbean and Andean regions may experience a reduction in precipitation of greater than 30 percent [11]. In the Caribbean region, this includes most of the coastline⁹ and the major coastal cities of Cartagena, Barranquilla, and Santa

Marta. La Guajira, home to the La Guajira Desert, is already one of the driest areas of Colombia.

The regions of the high Andes are also expected to receive a significant reduction in precipitation, with the reduction being most severe for the highest regions. The areas surrounding Huila Department will be among the most impacted, as will the area surrounding Bogotá. The models vary on their estimates of the impacts to the mountains of Nariño Department, with one scenario predicting between a 10 and 30 percent reduction and the other predicting a greater than 30 percent reduction. Most of the rest of the region in the high Andes will experience a reduction in precipitation of between 10 and 30 percent [11].

There are also a few areas, mostly in the Pacific region, that will receive significantly more precipitation than their historical average. Much of Choco Department and the coastal region near Buenaventura are expected to receive a more than 30 percent increase. This area includes regions that are already some of the wettest areas in the world. An increase of 30 percent in precipitation would mean an additional 2 meters per year. A small portion of Santander Department is also predicted to experience a 10 to 30 percent increase in annual precipitation [11].

The archipelago of San Andrés and Providencia, which currently averages between 1 and 1.5 meters per year, will receive between 10 and 30 percent less rain than experienced between 1961 and 1990 [11].

As with the temperature scenarios, when comparing the map of precipitation patterns with

⁹ This includes most of La Guajira Department; much of Córdoba, Sucre, Atlántico Departments; and the northern portions of Magdalena Department.

a map of where precipitation is already occurring, a general pattern emerges: the areas with the most precipitation will get even more; the areas that get the least will experience the most significant decreases.

Colombia will feel the effects of El Niño and La Niña more severely

Climate change will also impact one of the most important climate phenomena in the world: the El Niño-Southern Oscillation (ENSO), also known by its two phases of El Niño and La Niña.

ENSO events occur once every 2 to 7 years in the tropical Pacific, due to the interaction of the trade winds and the ocean surface. ENSO events are marked by two phases: the El Niño phase (where eastern and central Pacific water surface temperatures are warmer than usual) and the La Niña phase (where water surface temperatures are cooler than usual).

ENSO events already have a marked impact on Colombia. The El Niño phase is associated with droughts and forest fires, increased incidence of malaria and dengue fever, and negative impacts on electricity, fishing, and cattle production [15]. El Niño events can reduce water flows from Andean rivers by 30 percent and in some tributaries by 80 percent. In fact, during one El Niño event, the Magdalena River decreased its flow by 55 percent [16].

The La Niña phase is marked by heavy rain, floods, landslides, and increased erosion [15]. Because there are many factors that contribute to the climate of Colombia, the correlation of ENSO to these events is not one-to-one, but it is indeed present [17].

According to the IPCC, over the last 30 years, climate change has increased the frequency and intensity of ENSO events [2, 8]. The two worst El Niño events in South America were in 1982-1983 and 1998-1999. The former caused a 12 percent drop in Peru's gross domestic product; the latter brought severe drought to Colombia and a sea-level rise along the Pacific coast of 20 cm [8].

As climate change progresses, ENSO events and their impacts may be magnified across the region.



A Colombian army helicopter fights a forest fire in February 2007, a year when high temperatures caused numerous forest fires in the country. REUTERS/Jose Miguel Gomez

In the mountains: loss of glaciers and páramos

Colombia's landscape, history, development, and culture has been influenced significantly by the high peaks of the Andean mountain range. In regard to water resources, the Andean mountains play a critical role through their glacial peaks and unique ecosystems known as the páramos.

Glaciers will continue their retreat

There are glaciers on four areas within the ranges of the Sierra Nevada de Santa Marta, Cordillera Oriental, and Cordillera Central. Their most recent maximum extent was reached in 1850; since that time, the extent of Colombia's glaciers has diminished by 82 percent (from 348 km² to 63 km²) [2, 18]. Studies based on direct observation and satellite imagery have indicated that, while they have been shrinking since 1850, their retreat is now accelerating (due to warming temperatures, changes in humidity, and natural events such as volcanic eruptions) [2, 19]. Since 1950, Colombian glaciers have diminished in size by nearly 50 percent [19, 20].

The accelerated melting of the glaciers has the near-term impact of releasing more water into the Andean mountain ecosystem; in the long-term, the water in the region will decrease.

The IPCC states that Colombia is at-risk of losing all of its glaciers by the end of the century [16]; other experts believe this may occur by 2050 [21]. According to the IPCC, glacial retreat has reached "critical conditions" in Colombia (as well as in Peru, Bolivia, and Ecuador) [16].

Páramos ecosystems will be under significant pressure

While glaciers sit atop some of the highest peaks in Colombia, there is another high mountain ecosystem in the Andes that is of vital importance to the country: the páramo. Residing roughly between 3,000 meters (above the treeline) and below

5,000 meters (below the snow line), the páramo is an ecosystem defined by its unique biodiversity, its scattered grasses and large Rosette plants, its abundant mosses and lichens, and its water resources. The Colombian páramos are located along each of the Andean ranges (including the Sierra Nevada de Santa Marta), but are concentrated mainly in the northern portion of Cordillera Oriental [22].

The páramos play a critical role in supplying and moderating Colombia's water resources, and they face a serious threat from climate change. With their wet soils and abundant vegetation, páramos act as a sponge, absorbing enormous water reserves from the atmosphere and releasing them gradually. In effect, the páramos serve as the water tower for the nation. They provide constant and reliable water to many of Colombia's highly populated cities and most important river systems, including the Magdalena and Cauca¹⁰ [22-25]. In South America as a whole, it is estimated that 40 million people depend directly upon the páramos for their water, with another 70 million benefiting indirectly [26].

Climate change threatens to reduce and weaken the páramos through significant decreases in precipitation at high altitudes (greater than 30 percent) and warming temperatures. The resulting changes in moisture and cloud cover and the encroachment of lower Andean ecosystems into the range of the páramos could have significant

¹⁰ Bogotá's 8 million residents, for example, receive nearly 80 percent of their drinking water from the páramo in Chingaza National Park. The San Rafael reservoir located near Bogotá has enough water to supply the city with 3 to 5 months in the event of a drought.



A páramo at the Chingaza National Park outside of Bogotá, which provides around 80 percent of Bogotá's drinking water. The mist, spongy ground, and stream are typical features of the páramos. Photo courtesy of the authors. June, 2009.

negative impacts. IDEAM has predicted that impending climate change would affect virtually all of the páramos range and that 56 percent may disappear completely by 2050 [25]. These effects are worse when considered in the context of ongoing encroachment from agriculture and ranching activities, which may increase as warming temperatures push these activities into higher altitudes.

As a result, páramos will be pushed higher in altitude, shrinking their range [18]. Reduced in size and with less biodiversity, their ability to absorb water is diminished, and runoff, erosion, and sedimentation downstream are increased¹¹ [27, 28]. As a result, the flows of Colombia's main river systems are likely to diminish significantly, particularly during the dry season, and their volatility

will increase. This impact on Colombia's rivers and major watersheds will be magnified and expanded by the disappearance of Colombia's glaciers.

The diminishment and drying of the páramos does not of itself present any problems for national security. Downstream, however, the effects that weaker and unstable páramos are likely to have in terms of river flow (important for hydroelectric production), basic water provision, and agriculture could generate social crises.

¹¹ Because of these combined threats, IDEAM, The Nature Conservancy, the World Bank, the National Park Service, the Ministry of Environment, private companies, and the Bogotá Water and Sewage Company are all focused on the issue of conserving the paramos; a pilot project is underway in Chingaza National Park [22, 27].

In the rivers: increased seasonal volatility and flooding

The waters that flow out the Andean páramos and glaciers serve as the lifeblood of Colombia's winding network of large and small river systems. The headwaters of Colombia's largest and most important river system, the Magdalena, are in the mountains of Huila Department; these waters flow all the way through the country and into the Caribbean Sea at Barranquilla¹² [29]. Most of Colombia's other major river systems also have their source in the Andean chain.

There are 14,300 km of navigable rivers throughout the country [30]. Because roads do not exist in much of the Amazonia and Orinoco regions, rivers have historically provided the most common means of access to the country's many remote regions.

Colombia's illegal armed groups have also used the country's network of rivers to support their arms and narcotics trafficking operations. This is particularly so in the dense rainforests of the Amazonian region and in the sparsely inhabited Pacific coastal region.

Because of their critical role in Colombia, any impact to the navigability of the river system is of concern. Climate change will affect them through the combination of stronger El Niño/La Niña cycles, melting glaciers, disappearing páramos, and changing precipitation patterns; these impacts will exacerbate both the high and low flows of the

rivers. Because of the tendency for Colombians to live on or near rivers, and their importance to the nation's economic life, their flooding has traditionally been a critical problem to the nation's security.

Flooding will be more frequent and intense

The most prominent type of natural disaster in Colombia is flooding. Since 1980, Colombia has experienced significant flood disasters at an average of more than one per year. Due to its topography, Colombia also suffers from some of the most rapidly onset floods in the world [31]. Of Colombia's top ten disasters since 1980 (as measured by number of people affected), nine of the events were floods¹³.

While the flooding in Colombia does result in some fatalities, the displacement of people is of greater concern. On average, while Colombia's floods each kill around 34 people, they affect around 90,000 [32].

With the intensification of La Niña and significant increase in precipitation in certain regions, climate change threatens to increase the destruction caused by flooding in the nation's rivers. More frequent and intense flood events will likely serve to exacerbate the poverty and internal displacement of people within the country. While much of the nation is affected by widespread flooding, the highest concentration of victims live in an area of northern Colombia known as La Mojana. When viewed from a satellite, it is clear why this region floods: situated near where Sucre and Bolívar De-

¹² The Magdalena runs 1,500 km, covering a drainage basin of 250,000 km² (about one-fifth of Colombia's total area, equivalent to the size of Wyoming) [38].

¹³ Only the earthquake in 1999 surpassed the floods in the number of people that were affected [31].

partsments intersect, this region is where the Magdalena and Cauca Rivers meet; the surrounding areas of tributaries and bodies of water spread widely across the valley. In La Mojana, seven out of every ten households live below the poverty line [33]. As such, the floods contribute to human misery by destroying homes and infrastructure, ruining crops, polluting water supplies, causing disease, and driving people from their homes, sometimes permanently [34].

Flooding in Colombia is not limited to the La Mojana region. This can be seen by surveying a few of the noteworthy flood events in recent years:

- Extensive flooding due to heavy rains occurred in February of 2009. The Mira River in Nariño Department overflowed its banks due to the rain; as a result, thousands of homes in Tumaco were destroyed and more than 30,000 people were affected [35-37].
- In 2008, estimates of the population affected by floods ranged between 1.2 million and nearly 1.7 million [32, 38]. In May 2008, heavy rains in the mountains led to runoff that flooded the Magdalena and Cauca Rivers. Particularly hard hit were Honda, La Dorada, and Puerto Salgar. In total, 27 of Colombia's 32 Departments were affected [39]. In 2008, the Magdalena River reached its highest levels in 40 years [32].
- In 2007, more than 1.4 million Colombians were affected by flooding. The rainy season in 2007 resulted in floods that damaged or destroyed 270,000 homes and businesses. Most of the country was affected, with the worst effects in the north [40].



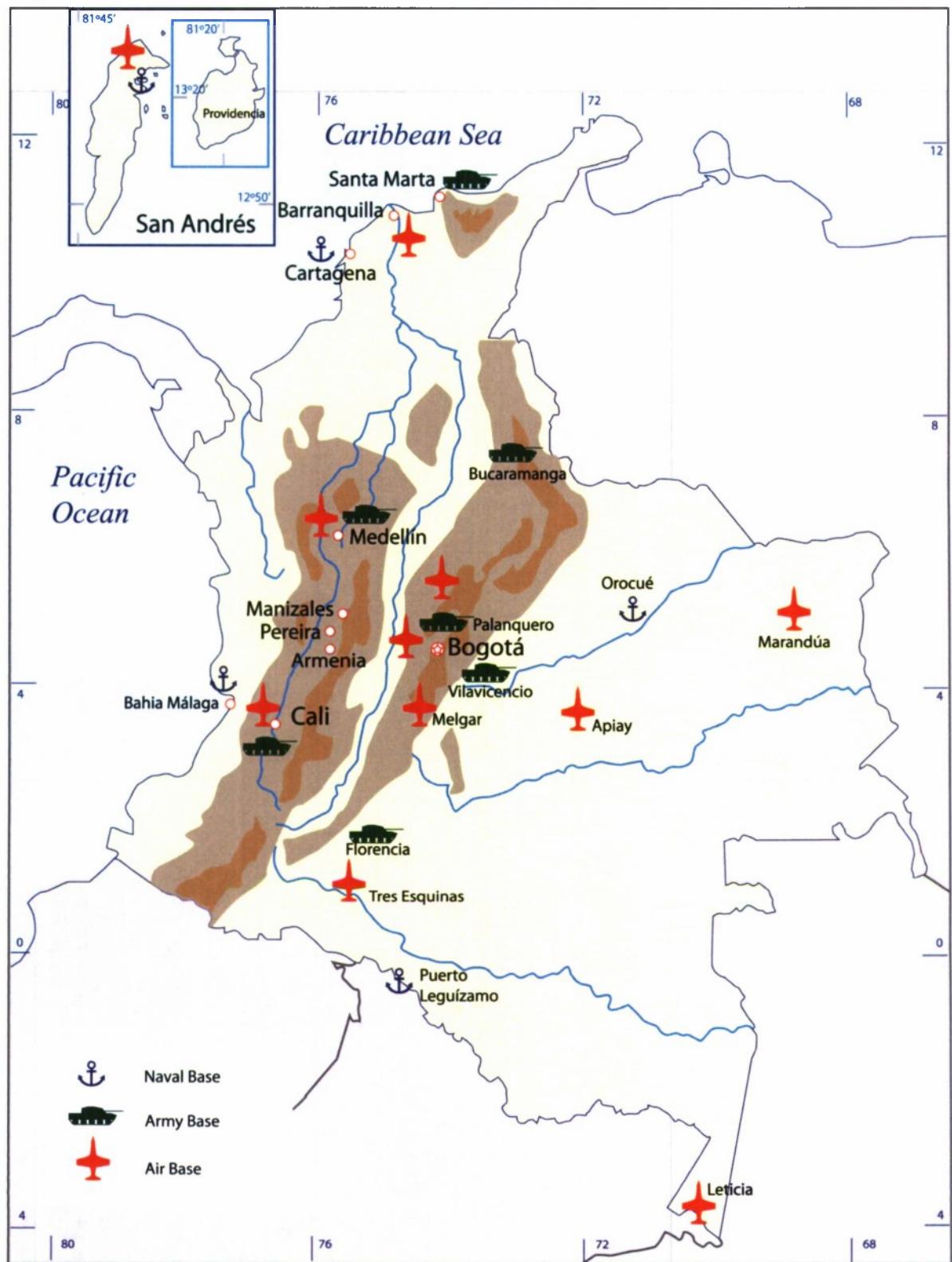
Recent flood victims in Colombia. Photo courtesy of the British Embassy in Bogotá.

The military will continue to be impacted by flooding

As flooding and other associated events (such as landslides and severe storms) increase in their intensity and continue to overwhelm the ability of local jurisdictions to respond, Colombia's government may look more frequently to its military resources to assist in relief, search and rescue, and recovery operations. The Colombian military already assists in these types of events by contributing airlift and food drops via helicopters and by performing local infrastructure projects.

However, the military and its main mission are also likely to be highly impacted by the flooding events along the river system. As can be seen in figure 3, many of Colombia's military installations are also co-located along river banks. For example, one of the Colombian Air Force's primary combat com-

Figure 3: Colombia's major military installations



mands, Air Combat Command 1, is located at the Germán Olano de Palanquero Air Base, Cundinamarca Department [41].

Palanquero Air Base, located on the shore of the Magdalena River 112 km northwest of Bogotá, is Colombia's most important military airport. Its 3.5 kilometer-long runway allows three simultaneous take-offs and its enormous hangar can hold 60 aircraft. Known in Colombia as "the home of the fighter jet," it is the site for the deployment of Colombia's Mirage 5 and K-fir jets. Palanquero Air Base also houses a fleet of AC-47 gunships and helicopters used for counter-insurgency missions. In close proximity to the Puerto Salgar Army Base, Palanquero Air Base is also the central point for troop transport and rapid response operations [41].

Most recently, Palanquero Air Base has been in the news because it is one of seven military bases that the U.S. will be allowed to use for regional counternarcotics operations under the new, 10 year-long US-Colombia Defense Co-operation Agreement announced in August 2009. This additional function—as the center for U.S. and Colombian surveillance flights and the processing of that information—makes Palanquero Air Base even more critical for Colombian national security.

The effects of climate change pose a significant threat to Palanquero Air Base. November 2008 brought the region's highest monthly volume of precipitation in 50 years, and the Magdalena and Cauca Rivers both overflowed their banks. Several local cities were flooded, and at one point the waters of the Magdalena reached the runway at Palanquero, almost prohibiting the take-off and landing of aircraft. Colombian Air Force officers stated that, the waters were less than a couple of meters away from shutting down Colombia's air support for its campaign against the FARC and its border control. The central pier for use by the air base and the nearby army base was also put out of service temporarily [42].

Considering the high probability of increasing, and more frequent, rainfall in the area over the coming decades as a result of warmer air temperatures, the improvement of Palanquero's defenses against flooding is of utmost concern to the Co-



Aerial view of the flooded area of the Magdalena River near La Dorada. May 29, 2009.
REUTERS/Ho New

lombian Air Force. Part of the funds for making these improvements will come from the United States, which, in exchange for the use of the base, agreed to invest US\$46 million in the upgrading of the base's operations.

The situation at Palanquero is far from unusual. When many of Colombia's military bases were established, support by air was conducted via hydroplanes. As a result, many of Colombia's most important bases are on the shores of rivers and also, like Palanquero, face future threats from flooding. Other bases that face similar threats from flooding and shore erosion include the Air Base at Tres Esquinas de Caquetá (where the Southern Air Group is based and provides support to army and marine operations near the Ecuadorian border) and the Air Base at Leticia (in the far southeast of the country).

Colombia's naval forces are also subject to the impacts of these severe riverine floods. Colombia's primary naval force in the interior of the country—Naval Forces South—is charged with protecting the areas around Colombia's two major southern rivers, the Putumayo River (which forms much of Colombia's border with Ecuador) and the Caquetá River. The facilities of Naval Forces South are based on the banks of the Putumayo River in Puerto Leguízamo [43].

Rivers will also experience periodic decreases in flow

During the dry season, reduced river flows are, and will continue to be, a concern to Colombia, mainly due to its impact on the energy infrastruc-

ture. El Niño events frequently cause reduced river flows, droughts, and increased temperatures. In fact, as noted earlier, El Niño events can reduce water flows from Andean rivers by 30 percent and in some tributaries by 80 percent. In one El Niño event, the flow of the Magdalena River decreased by 55 percent [16].

Reduced flow in the rivers is a concern because Colombia relies heavily on hydropower generated from the rivers born in the Andean range. Nearly two-thirds of its electrical power is generated this way; the balance of their electrical power is derived from thermal sources, such as natural gas and coal [17, 44].

The hydropower dams are located throughout the Andean region, using river water from the páramos, glaciers, and precipitation. Each of these inputs is expected to be impacted by climate change pressures in the coming decades. Colombia has already experienced negative consequences of basing such a large portion of its electricity generation on its system of dams. According to data on previous events, the power provided by hydropower can drop 10 to 30 percent in years of strong El Niños [27]. In fact, during the drought caused by an ENSO event in 1992-1993, electricity had to be rationed to 8 hours per day. This rationing was caused by the lack of multi-year storage capacity at most of the hydroelectric generators [44].

When considering the impacts to the rivers of climate-driven events, Colombia will likely have to continue to turn towards other methods of generating electricity and transform a significant portion of their energy-related infrastructure.

They have already begun this shift. Since the mid-1990s, Colombia has been lessening its dependence on hydropower by constructing natural gas and coal-fired power plants to meet its increasing demand [17].

River levels dictate tactics in the military's struggle against insurgents

Colombian marine corps officers stated that the rising and falling of river levels has definite impacts on operations in the southern and eastern regions of the country, where FARC and narcotics trafficking activity is intense. The FARC and other illegal armed groups adapt rapidly to take advantage of either the opening or closing of river

...there are two major issues of concern to Colombian agriculture: desertification and pestilence.

ine routes as well as in response to the military's efforts to close those routes. In some respects, the increased technological and material superiority of the military is a disadvantage when environmental conditions require flexible and rapid adjustments to mobility.

During the dry season between October and February, the closure of many river routes erases the advantage the Marines have in conducting riverine operations. A future scenario in which climate effects reduce precipitation and extend the dry season in the Savannah region will pose difficulties to Colombian efforts to solidify its control of the national territory and to protect its borders with Venezuela.

In the soil: regional desertification

Water is also a critical element of Colombia's agricultural sector, both in terms of moisture in the soil and precipitation. Due to agriculture's dependence on soil and climate properties, the impact of climate change on agricultural productivity is a concern for much of the world. Agriculture is a particularly important sector of the Colombian economy, contributing 9 percent to the gross domestic product and employing nearly 5 million Colombians (22 percent of the labor force).

In Colombia and Latin America as a whole, projections yield different results based on the models and assumptions used, and these projections vary widely within and across countries in the region. In general, the increases in temperature would negatively affect the production of many crops on the continent, but the increase in carbon dioxide could offset the temperature impacts [16]. In Colombia, these predictions are made more complicated by the wide variety of ecosystems and microclimates across the country [18].

Despite the varying predictions of the climate models, there are two major issues of concern to Colombian agriculture: desertification and pestilence.

About 7 percent of Colombia's land area is suitable to intensive agriculture, of which 12.2 percent is in dry areas. Desertification is already present in about 4.1 percent of Colombia (about 4.8 million hectares (ha)) [18]. The areas most impacted are the northern portion of La Guajira Department, the coastal areas of Sucre and Cordoba Departments, and portions of Cesar Department [11].



A coffee field in Quimbaya region within the Cauca River Valley, June 2009. Photo courtesy of the British Embassy.

There are also highly impacted but smaller regions north of Bogotá and around Cali. There are several areas of the high Andes that exhibit a moderate to high level of desertification. The islands of San Andrés and Providencia exhibit moderate desertification, with the northern portions of San Andrés being the most impacted [11].

For much of the northern portion of Colombia (which is already among the driest regions in the country), the combination of increased temperatures and lower annual precipitation will result in a decrease in soil moisture and an increase in desertification. Climate change, however, is not the only driver for desertification: intensive agricultural practices and extraction of resources (such as oil and coal) also contribute to the problem [18].

In one of their model predictions, IDEAM projects that desertification, focused mainly in the northern regions of the country, will increase by 1.4 percent in the dry ecosystems, thus impacting areas that

support bananas, sugar cane, and African palm [18].

Coffee production could be impacted

Not all threats to agriculture arise in regard to water. Because of its importance to the national economy, the impacts of climate change on coffee production are of particular concern. Coffee contributes more than a third of the revenues of the agricultural sector and employs more than 800,000 people (many of whom are in the

rural regions of the country). Colombia is also the third largest producer of coffee in the world [45].

The coffee growing region is located all along the Andean region, stretching from Nariño to La Guajira. Fifty to sixty percent of Colombia's coffee belt could be pushed into higher altitudes by the changes in the climate [18]. Coffee may be able to be produced in some of its traditional locations, but may suffer a decrease in productivity and quality [46]. Much of the future of coffee production in response to climate change depends on the degree to which adaptation measures are adopted to stem the impacts.

In addition to coffee lands being pushed into higher altitudes, there is also a potential increase in pests that affect coffee. In Colombia (and other coffee-growing regions around the world), researchers predict that climate change could result in an increase in the population of coffee berry borer, a pest highly damaging to coffee plants [47].

Security implications regarding coca production are unclear

As noted earlier, one of the prime security concerns in Colombia today is the cultivation of coca and the associated violence of the narcotraffickers and other illegal armed groups. Like other agricultural products, the coca plant is subject to environmental pressures [48]. However, as with other agricultural products, the impact of climate change on coca in Colombia is unclear. While coca is a hardy plant and grows under a range of conditions, it is also vulnerable to certain types of fungi. For example, in the early 1990s, Peru's coca crop was virtually annihilated by the root-eating fungus *fusarium oxysporum* [49]. As of yet there is no indication that fungi or other diseases that may affect coca will be impacted by climate change. Because the coca plant is well suited to much of Colombia's territory, the environmental changes alone do not seem likely to curb its production.

Given current conditions and patterns, it is more reasonable to assume that to some degree coca cultivation could increase in future decades (assuming consistent or growing demand) because it can substitute for crops hard hit by climate change. For example, coffee and coca can be grown in similar regions.

If coca cultivation were to increase in future decades, the income from this crop would likely go to support illicit activities as it does now. For this reason the impact of climate change on coca, and on other base plants for narcotics, presents an important gap in our ability to project future security effects. But no matter the crop, in Colombia agricultural shocks that reduce the incomes of local populations can lead to increased levels of violence,

including organized violence and insurgency. A recent study indicates that falling coffee prices between 1998 and 2002 increased both the incidence and intensity of Colombia's internal conflict, particularly in coffee-growing regions [50]. This connection between economic crises in agricultural zones and rising levels of politically motivated violence suggests that widespread climate-induced desertification, droughts, and pestilence could further inflame conflict in the countryside.

In the seas: sea-level rise

In regions all around the world, the IPCC projects that seas will rise between 0.20 meters and 0.51 meters by the end of the century as compared to levels between 1980 and 1999 (for scenarios A2 and B2) [51]. While these are the IPCC's official estimates, many scientists consider this prediction to be too conservative: the actual sea-level rise could be higher since the IPCC's estimates do not include the ongoing (and accelerating) melting of large land-based glaciers. Some more recent research has indicated that a sea-level rise of 1-meter by the end of the century is possible [52, 53].

Colombia will also feel the impacts of climate change through the rising of the seas that serve as its Pacific and Caribbean borders. Since 1951, sea levels have been rising by 0.22 meters on the Caribbean coast and 0.10 meters on the Pacific coast (at a rate of approximately 0.45 mm and 0.20 mm per year, respectively) [11].

Looking into the future, the coasts of Colombia—both the Pacific and Caribbean—will continue to experience a greater degree of sea level rise. By the 2050 to 2060 timeframe, IDEAM estimates that sea levels will rise by 0.40 meters along the Carib-

bean coast and by 0.60 meters along the Pacific coast as compared the average level between 1961 and 1990 [25].

IDEAM has assessed that 4,900² km of Colombia's coastline could be flooded permanently by a 1-meter rise in sea levels. This level of costal flooding would impact about 1.4 million people, with 85 percent of those affected living in urban areas [18]. This flooding would also impact approximately 353,000 ha of agricultural land [16, 18].

Rising seas also threaten to further salinize the fresh water ecosystems along the coastline, which could in turn salinate groundwater supplies and the surrounding land [11]. Aquifers along the Caribbean coast are already under threat of pollution, salination, and over-extraction due to poor water management.

Seas will rise along the Caribbean coast

The Caribbean coast line of Colombia is 1,030 km long, of which more than half consists of shores defined by fine particles of silt and clay [54]. Rocky and/or sandy beaches stretch from the Venezuelan border to Santa Marta; the remaining coastline is lined with mud flats, sandy beaches (some of which are backed by cliffs up to 100 meters high), and mangrove swamps [54]. Particularly substantial mangrove swamps are found near Ciénaga Grande de Santa Marta, the delta of the Magdalena River, Cartagena and Barbacoas Bays, and the Urbada Gulf [39, 54]. Tidal ranges are typically less than 2 meters on the Caribbean coast [55].

Along the Caribbean coast, the areas of Cartagena (the Caribbean coast's major city), Santa Marta, Turbo, and the Artrato Delta are of particular concern. Much of this region is heavily populated and features infrastructure that would be sensitive to

This level of coastal flooding would impact about 1.4 million people, with 85 percent of those affected living in urban areas.

sea-level rise of just 0.30 meters. As seas continue to rise over the century towards 1 meter, Barranquilla, one of Colombia's major ports, will become vulnerable to inundation. About 9 percent of the urban housing along the Caribbean coast would be vulnerable to flooding, while 46 percent in the rural area would be susceptible [18].

Cartagena is one of Colombia's oldest cities and is located on the central portion of the Caribbean coastline. Cartagena and its surrounding area are home to nearly 900,000 people; the city's economy is based primarily on tourism. Cartagena, however, is at severe risk from the water that surrounds it. Cartagena floods in the rainy season, when rising water comes up through the city's drainage system and floods the streets from within. For example, in November 2003, heavy rains and high tides combined to flood nearly 60 percent of the city [56].

Cartagena is also critical to Colombia's national security. The navy's primary base (ARC Bolívar) and headquarters of its Caribbean Force Command are located in Cartagena Bay. As such, the

naval fleet is concentrated at this base. The First Marine Brigade (one of three) is also under the command of the Caribbean Force Command [57]. As the years progress, rising seas, more frequent heavy rains, and stronger storm surges from hurricane activity in the Caribbean will have increasingly negative impacts on base operations. There is no other naval facility on the Caribbean coast. Losing the ability to operate, even temporarily, out of Cartagena would significantly impair the navy and marine corps counternarcotics and counterinsurgency operations.

As mentioned earlier, sea-level rise also presents a significant threat to the agricultural lands along the Caribbean coast. Of this land (consisting of 7.2 million ha), it is estimated that 4.9 percent is vulnerable to flooding, with nearly half of that area being highly vulnerable. As a result, some productivity in sugar cane, bananas, and African palms would be reduced [18].

Islands of San Andrés and Providencia face severe threat from sea-level rise

The archipelago of San Andrés and Providencia is located in the Caribbean Sea. Providencia is sparsely populated, but San Andrés has a population of approximately 75,000. Its people are mostly English speaking and of West Indian descent; however, since the 1970s significant numbers of Lebanese and Syrians, as well as other groups, have made San Andrés their home. San Andrés has operated for decades as a free port, and the smuggling of legal and illegal goods—including cocaine since the 1980s—has traditionally been part of the landscape. Recently, San Andrés has

also suffered from ethnic conflict and from rising rates of unemployment, drug use, and crime.

The people of San Andrés face in the future a combination of several likely severe climate-induced threats. Rising sea levels are expected to flood permanently a great part of the island's low-lying northern coast where virtually all of its tourism, key infrastructure, and the majority of its agricultural production are conducted. Recent projections indicate that 17 percent of the island will disappear within 50 years [66]. Sea-level rise is also expected to lead to the salination of many of the island's wells from which the population receives more than 80 percent of its water for daily use. San Andrés' aquifer has been in a state of stress due to salination since the 1980s and also suffers from chronic overexploitation. Under both of its scenarios, IDEAM projects that San Andrés will experience a temperature rise of up to 2° C and between a 10 and 30 percent decrease in precipitation. Because San Andrés already features some of Colombia's hottest temperatures (reaching above 32° C for much of the year) and a dry season that lasts 5 months, agriculture on the island could suffer. Finally, there is increasing risk of hurricanes in that region.

This combination of threats poses secondary risks of increased ethnic division and potential violence. Further poverty and destitution could induce outward migration and rising levels of crime among the population that remains. In order to protect public security, the government will need to provide many more resources than it has traditionally. Another problem is that the air base and coast guard station on San Andrés,

which are central to Colombian operations in the Caribbean, are also threatened by rising sea levels and storms.

Seas will rise along the Pacific coast

Much of the Pacific coastline (about 900 km) consists of a network of mangrove swamps and mud flats. There are also a few sections of coastal cliffs, mainly in the 300 km stretching north of Cabo Corrientes. There are also small sections northwest of Buenaventura and Tumaco. The San Juan, Patia, and Mira Rivers all feature mangrove-laden deltas [54]. Tidal ranges vary along the length of the coast, but are generally between 4 and 6 meters [55].

The potential for inundation due to rising seas along the Pacific coast intensifies going from north to south. Areas of major human activity, including Buenaventura and Tumaco, are a particular risk to a moderate sea-level rise of 0.30 meters. The areas at risk to a larger sea level rise of up to 1 meter are the same as those at risk of a 0.30 meter rise, but inundation would be more advanced [11]. About 48 percent of the housing along the urban areas of the Pacific coast would be susceptible to flooding, along with 87 percent of housing in rural areas [18].

Sea levels will continue to impact military operations on the Pacific coast

The Pacific coast has been a hotbed of activity for drug trafficking and illegal armed groups. Of drug seizures on the sea between 2002 and 2008, 86 percent occurred on the Pacific coast [48].

The residents of the coastline—including the FARC—generally are used to dramatic fluctuations in the sea level due to tides. At times, however, changes in sea level have presented complications to the Colombian military's efforts to stem the flow of drugs out of the country. When the tides are high, drug traffickers have employed go-fast boats to elude the military when travelling through the mouths of the rivers and out into the open ocean. In recent years, the traffickers have taken advantage of high river and sea levels by building small, fiberglass submarines that allow them to travel undetected and stay close to the coastline. Between 2005 and 2007, the Colombian navy seized nine of these vessels; the largest was 20 meters long [58]. The subs were capable of carrying approximately 5 tons of cocaine [59].

Conversely, when tides are low, travel between the rivers and Pacific Ocean is difficult. These low tides also mean that the movement of the Colombian navy and coast guard can be limited, an impact that does not go unnoticed by the drug traffickers and illegal armed groups.

During a low-tide event in December 1999, this limitation on mobility had tragic consequences. The marine corps had a small base in the town of Juradó, located in the northern portion of the Pacific coast about 15 km south of the Panamanian border. The base at Juradó was isolated, unreachable by road, and difficult for naval vessels to reach during low tide. At 0100 on 12 December, the FARC attacked the outpost with 600 men, eventually overrunning the base and killing all 26 marines stationed there. The FARC also destroyed a nearby police station. Even though a naval vessel

was offshore, it could not respond due to the low water levels. As often happens, the attacks forced the displacement of most of the town's residents to other cities on the coast, including Buenaventura and Solano Bay [60, 61].

As climate change advances, the climate conditions on the Pacific coast will worsen. Temperatures will rise even further. Increasingly heavy rains will be troublesome for military operations, hindering air support due to poor visibility. Also, heavier rains and higher surf will complicate coastal industries, and at times will likely cause flooding and humanitarian crises. This will result in a larger role for the military forces in the response phases.

The effects this might have on illegal armed groups are uncertain. They also will have to manage these changes; however, because their operations tend to be smaller and less dependent on technology and infrastructure, they can be expected to adapt rapidly to the new conditions. These groups will also have an advantage when military and police forces are required to respond to an increasing number of humanitarian disasters.

Summary

In Colombia, climate change will affect natural systems and resources most directly through its impact on water resources. These are likely to take the following forms:

- **In the air:** Precipitation patterns will change across the country (both increasing and decreasing, depending on the region). Extreme weather events, including hurricanes, heat-waves, wildfires, extreme rain storms, and El Niño/La Niña cycles, will become more frequent and intense.
- **In the mountains:** Warmer air and less humidity will threaten the Andean páramos, high-altitude wetlands that play a critical role in supplying and moderating the country's major river systems. The country's glaciers will continue to melt.
- **In the rivers:** River flow will diminish in general, particularly in the inter-Andean region, and river levels will be more volatile. Floods will increase in frequency and intensity.
- **In the soil:** Moisture levels in soils will decrease due to aridification, particularly in the Caribbean region and on high mountain plains. In these regions, rising temperatures will cause droughts of greater frequency and intensity. In other areas, flooding and volatile precipitation rates will increase soil erosion.
- **In the sea:** As with much of the rest of the world, climate change will increase sea levels on both of Colombia's coasts, inundating key areas of national, economic, cul-

tural, and military value. Rising seas will also threaten natural resources by polluting fresh water aquifers and mangroves with sea water.

These changes in Colombia's natural systems will impact its society, economy, and security in multiple ways. In most cases, climate change is unlikely to create entirely new security problems. Instead, it will act as a *threat multiplier*, exacerbating problems that already exist and stretching the capabilities and resources of the government, communities, and security forces for responding to these and other threats. Therefore, we assume that the future security implications of climate change in Colombia will not be entirely new phenomena, but familiar problems (e.g., drug trafficking and crime, natural disasters, and forced migration or displacement) that will be made worse in specific ways by climate change.

The security factors of most concern are:

- **Increases in the frequency and intensity of natural disasters.** These include floods, droughts, and (for the Caribbean coast) tropical storms. These impacts will increasingly overlap, having potentially severe humanitarian and economic effects.
- **Creating conditions that are conducive to illegal activities,** potentially worsening national crime and violence. Illegal armed groups and criminal organizations will benefit from climate-driven shocks and social disorder. The Colombian government, law enforcement agencies, and armed forces will be hard-pressed to respond to climate-related crises without di-

verting resources and attention from fighting crime and narcotraffickers. Also, illegal armed groups may have some tactical advantages in responding to changing climate conditions due to the relative flexibility in their operations. Any increase in drug trafficking and organized violence will not only affect Colombia's national security, but security across the Caribbean basin and beyond.

- **Exacerbation of human displacement.** Climate change could drive displacement, both domestic and international, as a result of the increase in natural disasters and environmental and societal impacts.
- **Growing pressure on the military's operations and resources.** While addressing their own needs to adapt their facilities and operations to climate change, the Colombian armed forces will be required to provide security assistance, along with civilian partners, to the public. The damage to their infrastructure and increase in complex humanitarian missions will serve to divert resources from other missions and operations.

Chapter 3

Climate change and regional security

Climate change will affect Colombia's neighbors as much as it will affect Colombia. These effects are already being felt in the form of droughts in Central America, the deaths of coral reefs in the Caribbean, and glacial melt in the Andes. Many of Colombia's neighbors meet these risks with weaker and less diverse economies, volatile social or ethnic divisions, and/or with severely challenged political systems. These conditions, if they persist, could reduce the abilities of these countries to respond to changes that may be abrupt and widespread. This poses several potential risks to regional security.

Virtually all Latin American countries agree that the greatest threats to the region's security relate to transnational phenomena. This consensus has given rise to numerous initiatives and associations that support international cooperation in areas including emergency assistance, law enforcement, and anti-trafficking. Colombia and the United States have played important roles in these initiatives. Looking to the future, the regional effects of climate change will demand regional responses. As a regional leader with highly capable and experienced armed forces, Colombia will be called upon not only to respond to its own crises, but also to those of its neighbors.

Security implications for the Caribbean basin

Colombia has important economic and security relations with the countries of Central America and the island countries of the Caribbean. The broader Caribbean basin (which includes Central America and the Caribbean coastal countries of South America, in addition to the Caribbean islands) and the Amazonian basin are the two regions of the Western Hemisphere expected to be most severely affected in a negative sense by climate change. The effects that are anticipated to have the greatest socio-economic impact include:

- **Hurricanes:** The warming of the ocean is expected to increase the intensity of the region's hurricanes, and they are likely to occur across a wider latitudinal range¹⁴. Some climate models suggest they will become more frequent as well. Economic projections from climate models indicate that the economic losses from hurricanes across the Caribbean basin (not including Mexico) during the period 2020-2025 will be 4 times greater—roughly US\$40 billion—than those suffered during average 5-year periods between 1979 and 2006. Moreover, these impacts are expected to continue to rise throughout the 21st century [62].
- **Water shortages:** Areas of Guatemala, Honduras, Nicaragua, and Panama are expected to

¹⁴ The first tropical cyclone to occur in the South Atlantic in recorded history hit Brazil in March 2004, destroying over 3,000 houses. See [67].

receive less precipitation under dramatically higher average temperatures. This will likely generate water shortages that will reduce the yields of traditional agricultural products, and increase rates of migration to urban areas and across borders. These effects are already evident in Guatemala and Nicaragua, where El Niño effects, combined with the failure of public services, are already causing famine in 2009 [63]. In the coming decades these crises are likely to occur frequently and be more intense.

- **Sea-level rise:** Rising sea levels will continue to threaten coastal infrastructure, local aquifers, fishing stocks and patterns, and livelihoods in every country of the region. In countries where most of the population lives along the coast as in Suriname or Guyana, estimated losses could approach a third of these nations' GDP [62]. When combined with the economic losses that come with the deaths of coral reefs that previously supported fishing stocks and tourism industries, the total effect on a small country's economy could be devastating.

Rather than creating new threats, we expect that climate change is likely to exacerbate existing security threats, and multiply their potential effects. In the case of the Caribbean basin, the impacts from climate change will further shape events relating at least to two existing security issues: the failing state of Haiti and competition over reduced water resources. It is also highly likely that low state resilience and the effects of climate change will combine to cause prolonged, widespread humanitarian crises, especially drought and famine.

Haiti's resilience is extremely low due to a lack of governance and public services, poor infrastructure, and the fact that its territory is already almost completely deforested. Regular tropical storms cause massive flooding, erosion, and mudslides. Climate change is expected to reduce precipitation and increase temperatures in Haiti, further burdens on what little agricultural activity still exists. As occurred in the spring of 2009, hurricanes could potentially spark immediate humanitarian and, potentially, political crises.

...longstanding conflicts over water resources may deepen as people demand remediation from their governments.

There are areas of Central America where the use of rivers and water resources are in dispute¹⁵. It is possible that in the coming years, these disputes, like many others, will be resolved peacefully and fade from regional relations. However, most have persisted for decades. Warming temperatures and declining levels of precipitation will likely reduce the water level and flow of most regional waterways, complicating their shared use. Also, changes in coastline from sea-level rise, as well as the decline of fishing stocks and other maritime resources, will cause social and economic stress in coastal communities. These longstanding conflicts over water resources may deepen as people demand remediation from their governments. In an interna-

¹⁵ Examples include the San Juan River that divides Nicaragua and Costa Rica, and conflicting maritime territorial claims between Nicaragua and Colombia; and Nicaragua, Honduras and El Salvador over the Gulf of Fonseca.

tional climate characterized by intense feelings of nationalism, these shortages could prove a source of international tension.

Some countries of the region already experience severe negative effects during cyclical periods of drought, often related to the El Niño phenomenon. Guatemala is currently struggling to respond to famine, and Nicaragua is expected to experience famine in early 2010 [53]. In future decades, warmer temperatures will likely magnify the effects of El Niño, causing severe, widespread drought, and La Niña, causing flooding. The resulting humanitarian crises will present all the countries of the region with recurring, virtually constant pressures for assistance and humanitarian aid. Outward migration from these countries will also continue to grow under such circumstances.

Security implications for the Andean region

The countries of the Andean region are likely to be more resilient, in general, than their smaller Caribbean neighbors, though there is enormous diversity in the region. Ecuador, Peru, and Chile have relatively diverse, industrialized economies and greater domestic resources and state capacities for adaptation. Bolivia, on the other hand, is among the hemisphere's poorest nations. Although relatively wealthy due to revenues from its oil exports, Venezuela's economy and industries are deteriorating rapidly. Changes in the global price for oil and oil consumption (which is expected to fall as alternative energies grow more available) will have major effects, most significantly for Venezu-

ela and Ecuador. The Andean region also suffers, in general, from exceptional levels of political instability.

The effects of climate change in the Andean region are expected to be less acute than those projected for the Caribbean basin. However, the most prominent effect—the decline of high-altitude water resources—presents enormous challenges and risks, including in terms of security.

As in Colombia, the regions of these Andean countries most vulnerable to rising air temperatures are the high-altitude zones. These zones are vital to these countries' societies and economies: by storing (as snowpack, glaciers, or páramos) and releasing water, they are the source of much of these countries' fresh water resources. Glacial melt is already occurring and is expected to continue until approximately 2050, when most are expected to have disappeared. This process is expected to have the following potentially critical effects:

- Several major cities, including La Paz, Quito, and Lima, obtain like Bogotá a significant portion of their public water supply from glacial or páramo runoff. These municipalities and nations face the need for enormously expensive new dams and reservoir systems in order to protect their long-term viability. Roughly 40 million people depend directly on water resources from páramos [26].
- In the coming decades, rapid glacial melting is likely to cause floods, mudslides, and other dangerous weather-related events, particularly in mountain canyons. In later decades, once these resources have largely disappeared, the

hydrological systems they feed will stabilize but at a much lower level of flow. This will threaten the sustainability of hydroelectric plants and other industry and agriculture that depend on these flows.

Managing the effects of this disappearance of high-altitude water resources will be extremely costly. It will require years of planning, the construction of new infrastructure, and the careful administration of these efforts via cooperation between the federal, departmental, and local authorities. Some of these countries, however, are among the least politically stable of the hemisphere and are currently undergoing processes of major political transition. If recent history is any indication, efforts on the part of these countries' governments, industries, and communities will be complicated by political division between regional groups, urban and rural blocks, and different ethnicities. The problems—increased flooding, accompanied by declining water supplies—and their solutions both have the potential to spark conflict, which could potentially become violent and even spill across borders.

Even if these governments are able to respond effectively enough to avoid this danger, such massive and relatively rapid economic change is likely to induce large-scale migration. Most of this would likely be from rural to urban areas within these countries, adding to the public need for services in the major cities. At least some, however, could cross borders (including into Colombia, if its economy were less negatively affected).

As in Central America, the overall regional decline in precipitation and reduced groundwater

flow from the loss of glaciers, snowpack, or páramos will mean lower water levels in many major regional waterways. The Orinoco River is Venezuela's principal waterway and a major source for irrigation and transport in that country. Its headwaters are mostly located in Colombia. Declining volume could pose significant problems for Venezuela. Without effective regional cooperation, disputes over the use of these water resources could translate into international tensions.

The following are anticipated security problems in the Caribbean basin and Andean region:

- Humanitarian crises (floods, droughts, famine, epidemics)
- Massive flows of refugees, both domestic and across borders
- Increasing crime, including organized crime (the trafficking of illicit goods)
- Elevated risk of political instability, social conflict, and violence as a result of widespread crises and the failure of some states to respond adequately
- Elevated risk of interstate tensions in certain areas, due to the declining levels of cross-border river systems

Security implications for Colombia

Several of these phenomena could pose a threat to Colombia's security. Colombia's military campaign against insurgent groups and drug cartels has generated unprecedented numbers of displaced people, including into other countries. The

anticipated climate effects in the region, coupled with differing levels of country resilience, suggest that in the future this pattern may be reversed. Colombia may be required to respond to the needs of thousands of refugees from neighboring countries, driven by crises (such as natural disasters or famines) and seeking stable living conditions.

Climate-driven impacts in the region are likely to generate more frequent and widespread humanitarian crises, which could drive masses of people across borders and into the fringes of cities. These flows will require enormous levels of state resources. In addition to their extensive needs for assistance, displaced populations are extremely vulnerable to exploitation by criminal groups, including for recruitment into criminal and illegally armed organizations. It is likely that the trafficking of illicit goods and humans will continue under the control of criminal cartels, and it is possible that armed insurgent groups will also still be in operation. Therefore while not a threat themselves, refugee flows contribute to conditions that promote increased levels of crime, including organized crime and armed insurgencies.

It is less likely, though not impossible, that the effects of climate change will cause societal and political shocks in neighboring countries that generate significant security threats for Colombia. Societies that are already fragmented across social classes and/or ethnicities, when struck by severe crises, may deteriorate further into open conflict. This is especially true when national political systems are weak, when they are themselves the instruments of division and conflict, and/or when public institutions are incapable of responding effectively to these shocks. Under such circumstances, open conflict

could erupt and might lead to large-scale outward migration as people flee from violence. Worse, nationalistic governments could focus blame for the

...while not a threat themselves, refugee flows contribute to conditions that promote increased levels of crime, including organized crime and armed insurgencies.

crisis on external factors including neighboring countries. Any combination of these factors could threaten regional peace.

Security implications for the United States

Over the first decade of the 21st century, Colombia and the United States formed an exceptionally close partnership, particularly in the area of security cooperation. Colombia's strategic importance to the United States is evident from the US\$6.4 billion of aid and assistance the U.S. has given Colombia from 2001 to 2008, in large part for its cooperation in fighting against the production and trafficking of narcotics. The August 2009 Defense Cooperation Agreement, which allows the U.S. to use for 10 years Colombian military facilities for its counternarcotics surveillance missions in exchange for further resources and cooperation, ensures this relationship will deepen into the future.

Because of Colombia's importance, the United States is likely to experience two secondary effects from the impacts of climate change in Colombia. First, Colombian producers provide around 90

percent of the cocaine and much of the heroin that reach U.S. consumers. For this reason, any increase in Colombian production—due to stresses on other crops, or other factors potentially related to climate change—would translate into deeper law enforcement problems within the United States. As narcotics traffickers change their tactics in response to changing climate conditions, the U.S. will likewise have to evolve in its cooperation with the Colombian military and police to continue to

...it is of enormous importance that cooperative regional security institutions become more viable and effective in the coming years.

support this shared mission. Growing security collaboration among the United States, Colombia, and the governments, law enforcement agencies, and armed forces of Mexico and the countries of Central America will likely make these efforts more international in the future.

For decades, the United States has been the regional leader in terms of disaster response and humanitarian assistance. The capabilities of the U.S. military, via the U.S. Southern Command, for rapid response and the large-scale delivery of emergency teams, aid, and essential equipment, are unparalleled in the region. In the future, as climate-driven crises such as hurricanes, floods, and droughts become increasingly frequent and intense, the United States will almost certainly be called upon to respond. Although emergency assistance is a traditional mission of the U.S. South-

ern Command, the U.S. Coast Guard, and other security agencies, the growing need for these operations could divert significant resources from other regional missions and activities.

Critical need for robust regional security institutions

We anticipate that Colombia, along with other countries in the region that are likely to be resilient in response to climate change and that have relatively good capabilities for disaster response, will bear a large share of the task of regional emergency assistance. The same is true for the mediation of regional political crises, which if it fails could lead to regional instability and security risks. These are significant burdens that future governments may have to undertake. One factor that will in large part determine the extent to which this burden is more broadly shared, or is disproportionately placed on countries including Colombia, will be the capabilities of cooperative regional security institutions.

The United States has traditionally been a regional leader in disaster response. However, the degree to which the United States will continue to be able and willing to support the region in these missions is uncertain. On one hand, events in the region will continue to affect U.S. security, and the United States will maintain its commitment to regional partners. By 2050, the U.S. population is expected to be roughly 30 percent Latino, which should increase U.S. willingness to assist and partner with its southern neighbors. On the other hand, global and national economic trends suggest that the resources (military and econom-

ic) that the United States will be able and willing to dedicate to the region will likely diminish. The more the attention in Washington is drawn to conflicts or threats in the Middle East or other regions, the less time and resources it can dedicate to its regional partners.

Other economic powers, particularly China and Brazil, are increasingly invested in the region and could possibly become significantly engaged in crisis response efforts. It appears unlikely, however, that in the coming decades these countries will contemplate dedicating financial and defense resources to develop or to assist the region significantly.

For these reasons it is of enormous importance that cooperative regional security institutions become more viable and effective in the coming years¹⁶. Ad hoc responses to crises tend to be expensive, slow, and inefficient. They also are more likely to fall disproportionately on the partners that are affected most directly or are most capable of responding. Decades in the future, Colombia is likely to fit both descriptions. For this reason, the entire region—but Colombia and the United States in particular—would benefit enormously from the strengthening of regional institutions capable of planning for and managing collective responses to the crises that will emerge from climate change¹⁷.

National and regional responses to the effects of climate change will in large part involve financing for development and adaptation projects, as well as prolonged assistance for affected populations, more than short-term military missions. Public international funding entities like the World Bank and the Inter-American Development Bank will likely struggle to meet these demands. As will likely be the case within Colombia, at the international level the enormous demand for funds for climate adaptation, new infrastructure, and emergency relief will likely exceed the abilities or willingness of the international community to pay. Colombia and its neighbors should advocate for international institutions to include climate effects and needs for adaptation into their budgets.

Summary

In summary, climate change will likely impact Colombia's security at the regional level in the following ways:

- **High demand for international emergency response.** It is highly likely that Colombia, with its relatively stable economy and greater infrastructural and military capabilities for emergency response operations, will be called upon to assist neighboring countries suffering climate-related crises.

- **Large-scale refugee flows are likely in the wake of some potentially devastating events such as drought, food, or water shortages.** These flows may also be driven by political conflicts caused partly by such crises. Some of these refugee flows may be transnational.

¹⁶ For an insightful discussion of this theme, see [65].

¹⁷ These include, for example, the Organization of American States (OAS), the Inter-American Defense Board, the South American Defense Council, CARICOM, and the Conference of Central American Armed Forces (CFAC).

- **Social stress could lead to political tensions.** It is possible that climate-induced crises, such as drought or famine, may combine with conditions of intense social division or nationalism to spark international tensions.
- **Humanitarian and economic crises facilitate illicit activities.** Around the region these economic and social difficulties will provide conditions that favor illicit activities such as the trafficking of drugs, humans, and other contraband, with their significant social and economic costs.
- **Limited public resources for response.** Regional governments will have to take measures to mitigate the effects of climate change (e.g., building and repairing dams, ports, power plants, etc.) that will likely outstrip available financial resources, both domestic and international. These burdens will reduce the regional capacity for emergency response and other security-related missions.
- **Spillover effects across the hemisphere.** The security impacts in Colombia could also have secondary security impacts for countries beyond the region, such as the United States, in terms of worsening problems of trafficking and crime, and increasing demand for humanitarian relief and crisis response.

Conclusion

Colombia's ecological and human systems will experience various impacts from climate change for the remainder of this century and beyond. Some of these impacts are likely to be severe enough to affect the nation's security, particularly in terms of citizens' security in their daily lives. For example, floods, droughts, storms, and El Niño/La Niña-related phenomena will be increasingly frequent and intense, and will often overlap, threatening to generate massive humanitarian and economic costs. Agricultural and industrial patterns will change, though the contours of these changes are difficult to predict.

The societal stress, migration, and misery that these effects of climate change may cause will likely lead desperate people to engage in criminal activities, or even organized armed violence. Colombia's government and military, which will have to mitigate the effects of climate impacts by adaptation in their own assets and systems, will be hard-pressed for the resources and services needed to help the public respond effectively to these combinations of effects.

These patterns will be echoed at the regional level. Long-term changes in agricultural and economic activities, which will affect whole regions, will be punctuated by intense storms and disasters and the spread of diseases that will threaten lives. Colombia's neighbors may not have the resources and public institutions to respond effectively, meaning that local crises could result in the transnational flows of refugees. Under conditions of political instability and polarized societies, ex-

tended droughts or water or food shortages can set off civil conflict, which may also spread across borders. At the international level as well as the domestic, the resources of governments and relief agencies—which will face cries of need from around the world—will likely be outstripped by the demand for assistance.

Fortunately, the Colombian government, civil society organizations, and the armed forces have already begun to consider these possibilities and to take measures to avoid the realization of the worst-case effects. IDEAM's National Integrated Pilot for Adaptation (INAP), for example, is a set of small programs testing strategies for improving adaptation in regard to high mountain ranges, islands, and human health. With support from the Netherlands, Colombian researchers recently assessed the vulnerability of the populations of Tumaco and Cartagena. Ongoing efforts to improve the country's energy efficiency and to diversify energy sources are also important. In addition, the protection of páramos, forests, and other ecosystems today will improve conditions for their survival in the face of higher temperatures and, most likely, increased human use in the future.

We hope that this modest set of considerations helps to promote further efforts of this sort as well as the long-term planning that Colombia, like all countries, will need to engage in to mitigate future impacts from climate change.

Appendix: Data Sources

The findings in this report are based on a variety of secondary and original research. The chief source for our estimates of future climate change impacts in Colombia is the Colombia's Institute for Hydrology, Meteorology, and Environmental Research (IDEAM), which manages the country's environmental information and data and produces reports to support decision-makers. IDEAM is also the primary organization in Colombia responsible for climate modeling and analysis in support of the IPCC¹⁸. This research was supplemented by interviews with several other Colombian governmental agencies, and with experts at the World Bank, the Inter-American Development Bank, and the Nature Conservancy—Colombia. CNA conducted no original analysis about anticipated climate effects.

Data on Colombia's geography, infrastructure, demographics, and economy also came via these interviews with Colombian government officials and with experts at the Office of the UN High Commissioner for Refugees in Bogotá, the Colombian Mining Industry Association (ANDI), and the UN Office for the Coordination of Humanitarian Affairs. In addition to these interviews, one source we found exceptionally useful is the *Atlas de Colombia* produced by the Instituto Geográfico Agustín Codazzi [64].

CNA consulted several sources regarding current and future security issues facing Colombia. In addition to a review of relevant literature, analysts visited Bogotá to meet with officers and analysts at the Ministry of Defense, the National War College (*Escuela Superior de Guerra*), the Foundation Ideas for Peace (*Fundación Ideas Para La Paz*), and the UN Office of Drugs and Crime. Interviews with the government social programs office *Acción Social*, Colombian Red Cross, and the Bogotá office of the United Nations High Commissioner for Refugees helped us understand the range and depth of human security issues that the country faces.

None of these organizations participated in the analytical process. CNA alone is responsible for the findings in this report.

¹⁸ The IPCC is the world's leading organization in examining the impacts of climate change to the planet. Founded by the United Nations Environment Program and the World Health Organization in 1989, the scientists that make up the IPCC have issued reports on a regular basis to assess the status of the world's climate (using the latest peer-reviewed scientific research) and inform decision-makers from around the world. Their reports, issued in 1990, 1995, 2001, and 2007, have proven influential; they are accepted as the most authoritative voice on global climate change. See: <http://www.ipcc.ch/>

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